The information in this booklet must not be given to the public

British Rail Train Crew Manual

Class 81,85,86 and 87 Locomotives

General Information & Driving Instructions

NOTE :- REFERENCES TO CLASS 81+85 LOCOS HAVE BEEN DELETED IN GREEN, PJL 12/91

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Supersedes
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FOREWORD

To standardise terminology the names of certain controls used in the previous publication BR. 33056/40 have been changed to bring them into line with those used for diesel traction i.e.

Control key	–	now master key
Reversing lever	–	now master switch
Notching lever	–	now power controller

1. INTRODUCTION

For the introduction of electric services on the West Coast Main Line (WCML) seven classes of electric locomotive were built, of which only four – Classes ~~81, 85~~, 86 & 87 – remain in main line service:-

Class	Electrical Equipment	Manufactured
~~84~~	~~British Thomson Houston (B.T.H.)~~	~~Birmingham Railway Carriage & Wagon (B.R.C.W).~~
~~85~~	~~Associated Electrical Industries (A.E.I)~~	~~British Rail~~
86	A.E.I. and English Electric Co.	British Rail
87	General Electric Co. (G.E.C.) Traction Ltd.	British Rail

~~All Class 84 locomotives have been withdrawn and those remaining of Class 82 and 83 are confined to ECS duties in the London area and are to be withdrawn in the near future.~~

Classes 86 & 87 have a number of sub-divisions:

~~86/0~~ Numbered between 86001 and 86039 – The original locomotives of this Class with A.E.I. 282AZ traction motors, rated at 3600 hp and now restricted to a maximum speed of 80 m.p.h. To be converted to 86/4.

86/1 Numbered between 86101 and 86103 – Rebuilt with Flexicoil suspension and G.E.C. traction motors as the prototypes for the later Class 87, rated at 5000 hp and suitable for 100 m.p.h. running.

86/2 Numbered between 86204 and 86261 – Rebuilt with Flexicoil suspension and A.E.I. 282BZ traction motors, rated at 4040 hp and suitable for 100 m.p.h. running.

86/3 Numbered between 86320 and 86329 – Rebuilt with S.A.B. resilient wheels, still rated at 3600 hp and suitable for 100 m.p.h. running. To be converted to 86/4.

86/4 Basically 86/0 and 86/3 rebuilt with Flexicoil suspension and S.A.B. resilient wheels as necessary, suitable for 100 m.p.h. running.

86/6 - 75MPH NO ETH

87/0 Numbered between 87001 and 87035 – Equipped with conventional electrical control equipment and rated at 5000 hp. Selected locomotives fitted with Brecknell-Willis pantographs and suitable for 110 m.p.h. running, the remainder limited to 100 m.p.h. maximum.

87/1 Numbered 87101 – As 87/0 but with thyristor electrical control equipment.

Locomotives of Class 86/0, 86/3, 86/4 and 87 are equipped for multiple working.

2. DRIVING COMPARTMENT

The driving compartment arrangements are basically similar for all Classes, those for Classes 86 and 87 being depicted in Figs. 1 and 2 pages 4 and 5 whilst the driving controls are shown in more detail in Figs. 3 and 4, pages 6 and 7.

2.1 The master controller unit, to the right of the driving position, has three mechanically interlocked contols (see Fig. 5 page 8):-

2.1.1. Master key position, into which the master key is inserted and turned to unlock the master switch.

Parking brake applies both blocks on leading wheelset

2.1.2. Master switch with three positions – FORWARD, OFF and REVERSE. The master switch handle must always correspond to the intended direction of travel, or the direction in which the locomotive is travelling. It MUST NOT be moved to the OFF position whilst the locomotive is moving, neither must it be moved to the opposite direction until the locomotive has actually stopped. A further interlock mechanism, operated by depressing a push button on the driving desk, prevents inadvertent movement of the master switch to reverse.

Certain locomotives are Speed Sensing Fitted (SSF) in that equipment is fitted to ensure that if the master switch is inadvertently moved to the OFF position whilst the locomotive is moving, or before it has been at a stand for 3-4 seconds, then a DSD brake application will be initiated. To reset the DSD equipment it will be necessary to depress the DSD pedal and select FOR or REV. Once the brakes have been released the master switch may be returned to OFF and the DSD pedal released.

Note if parking applied on locos fitted with buzzer DSD will apply when direction selected

2.1.3. Power controller, the handle of which is interlocked with the master switch so that it cannot be opened until FORWARD or REVERSE has been selected. It has six positions:-

OFF	The traction motor contactors are 'open' hence no power can reach the traction motors.
RUN DOWN	To be used to reduce power when the desired speed is attained, or to quickly reduce the notch position prior to moving the power controller to OFF. This avoids a sudden 'chopping off' of power as the secondary and motor contactors 'open' which could produce 'draw-bar' shocks along the train.
NOTCH DOWN	To be used to reduce power one notch at a time by moving the power controller 'to and fro' between the HOLD and NOTCH DOWN positions. Each complete movement reduces the tapchanger position by one notch.

Fig. 1 Class 86 locomotive

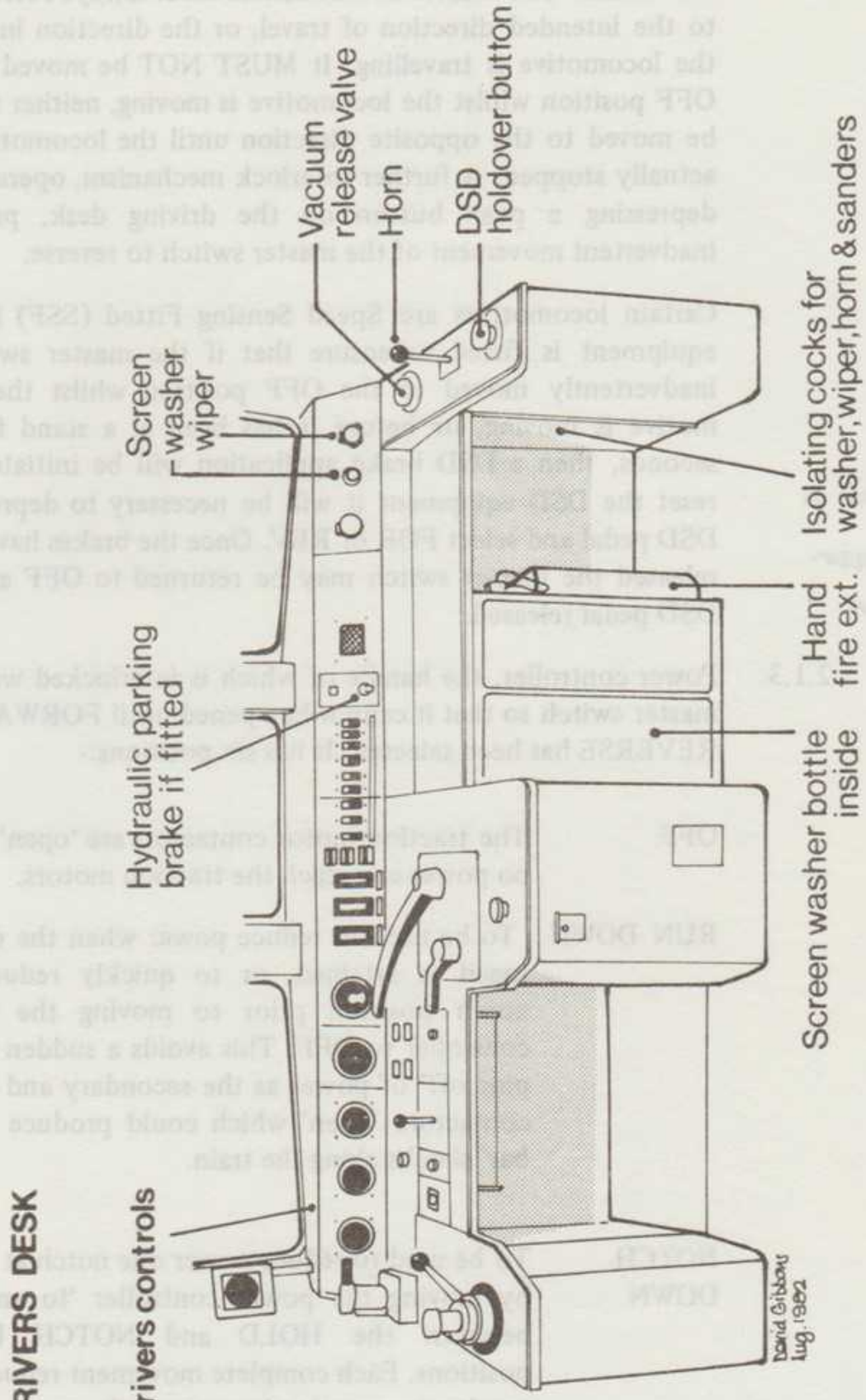
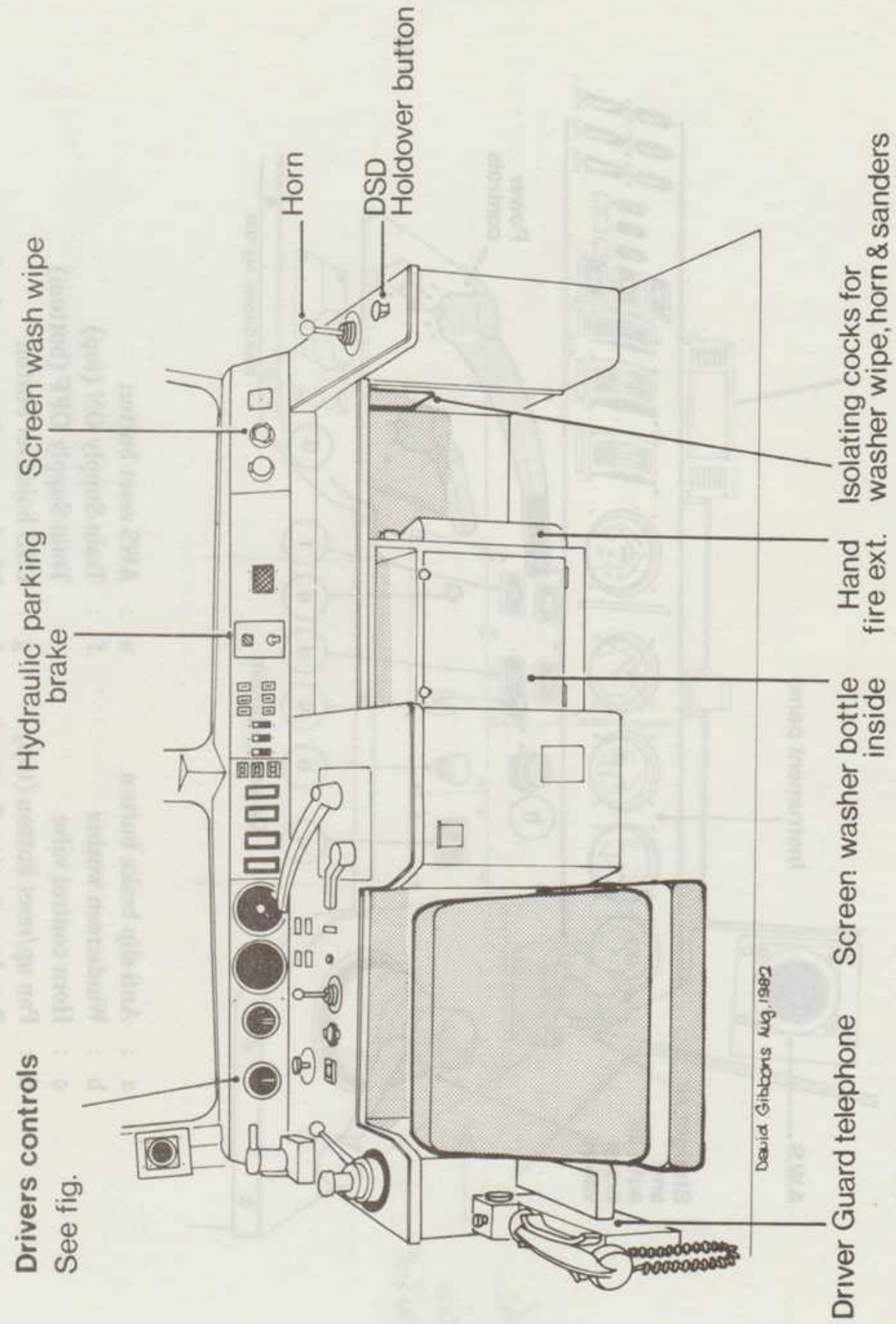


Fig. 2 Class 87 locomotive



DRIVERS CONTROLS

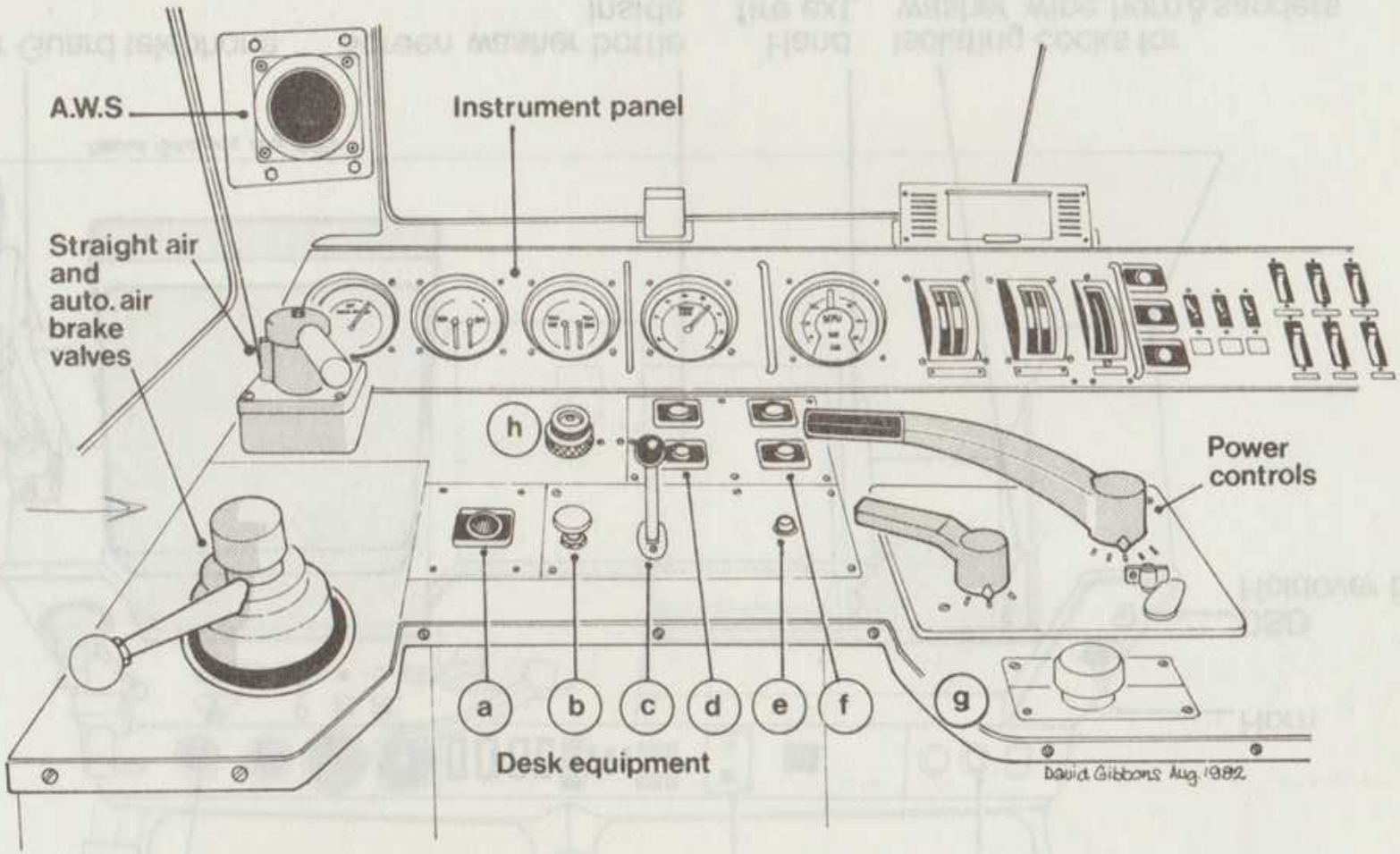


Fig. 3 Class 86 locomotive

a : Anti-slip brake button
b : Windscreen washer
c : Horn control valve
d : Pan up/reset button (top)
Pan down button (bottom)
e : AWS reset button
f : Train Supply ON (top)
Train Supply OFF (bottom)
g : DSD holdover button
h : Windscreen wiper control valve

Fig. 4 Class 87 Drivers controls

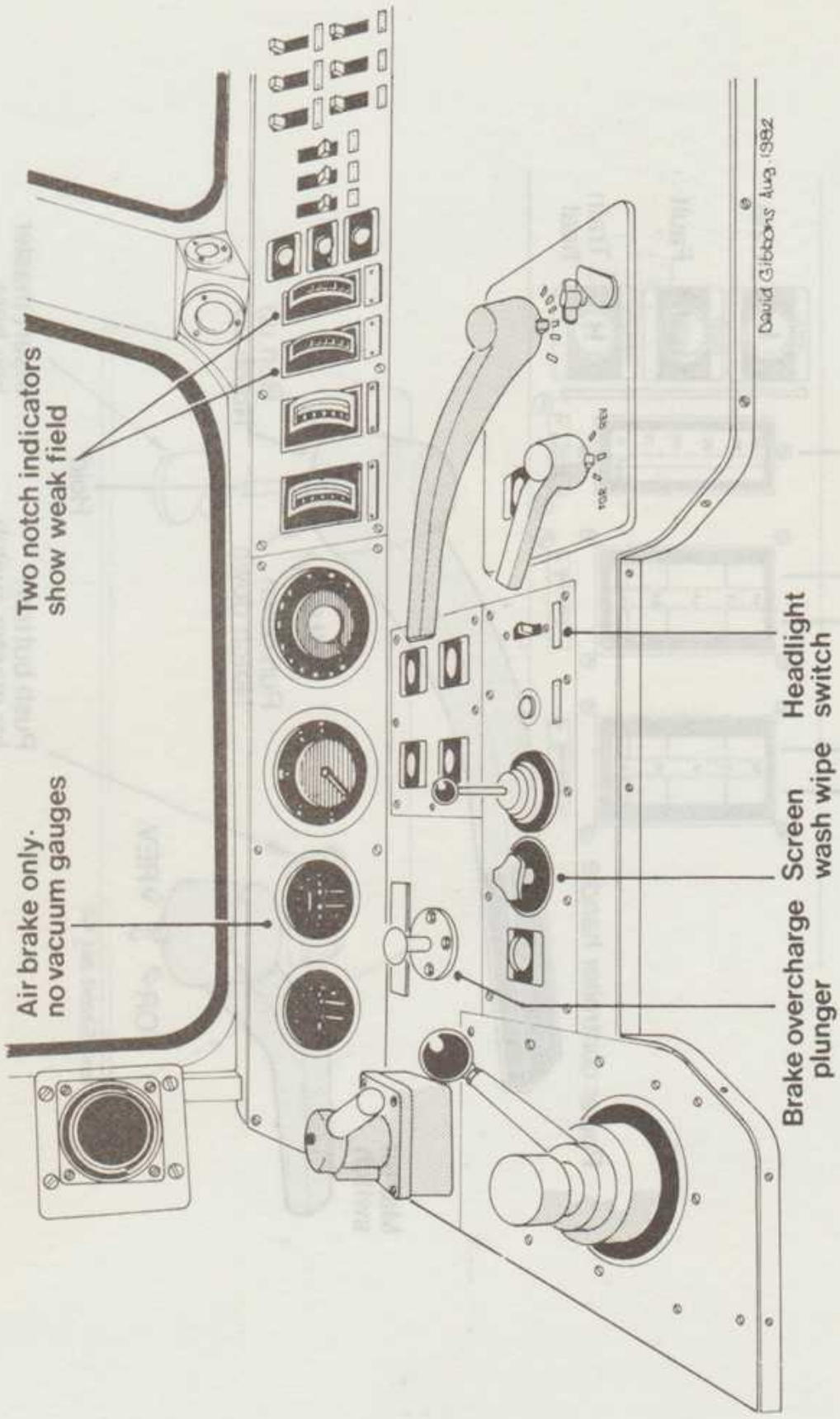
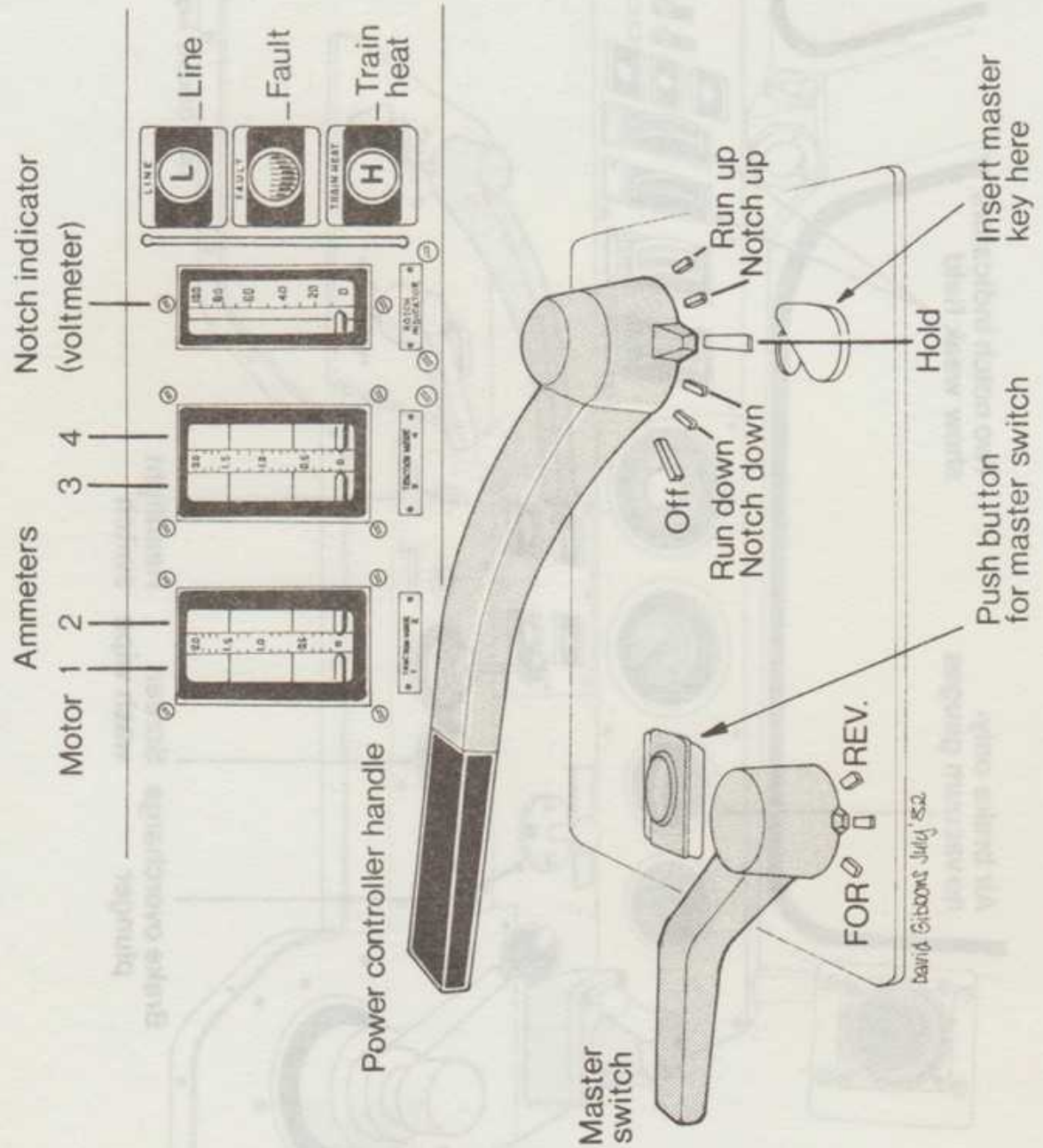


Fig. 5 Power Controls



HOLD — Used to retain the selected notch/tapchanger position once the desired speed has been attained.

NOTCH UP — To be used for the gradual application of power when starting trains away, or to increase power by small amounts whilst running. By moving the power controller 'to and fro' between HOLD and NOTCH UP the notch/tapchanger position can be increased one at a time over the whole of the notching range. During 'notching up' the traction motor ammeters should be observed to ensure that the ammeter needles do not remain in the RED sector for long periods, and that they remain approximately 'level'.

RUN UP — To be used to increase power rapidly when, say, power has been shut off or reduced for coasting at speed, by notching up the tapchanger automatically. The power controller is spring loaded in this position and will return to the NOTCH UP position when released.

The RUN UP position MUST NOT be used when starting a train from a standstill to avoid overloading the traction motors.

2.2 Pantograph Controls

2.2.1. Pan Up /Reset button – Only operative with the power controller at OFF and the master switch at FORWARD or REVERSE. When depressed it will (a) raise the pantograph (if not already up) and (b) reset various overload relays. When released, after the pantograph has made contact with the overhead line, the main circuit breaker will then 'set' therefore it is important that it is kept depressed for at least ten seconds when the pantograph is to be raised.

2.2.2. Pan Down button – Operative in all positions of the master switch. When depressed it will 'trip' the main circuit breaker and then lower the pantograph.

2.3 Electric Train Supply (ETS) Controls

2.3.1. Train Heat ON button – Operative with the master switch at FORWARD or REVERSE (Classes 81, 85 and 86), or at all positions (Class 87). Providing the Line Indicator Light is illuminated and the ETS jumper cables are correctly coupled a 800-1000 volt a.c. supply to the train is established and the train supply indicator light 'H' remains illuminated when the ON button is depressed and released.

2.3.2. Train Heat OFF button – Operative in all position of the master switch.

2.4 Sanding Controls – a foot operated button is provided which, when depressed, applies sand to the rails ahead of the leading axle.

2.5 Anti-Slip Control – A push button on the driving desk which, when depressed, initiates a partial bogie brake application on the locomotive This should be used on starting away when rail head conditions are poor and should be kept depressed during initial acceleration so that the brake blocks 'rub' the wheels and reduce the chances of wheel-slip/wheelspin. This anti-slip brake application MUST NOT be used in excess of 60 m.p.h. i.e. to counter wheelspin at higher speeds which sometimes occurs.

2.6 Driver to Guard telephone equipment is provided on certain locomotives – see Fig. 7 page 12.

2.7 Some Class 86 and all Class 87 locomotives are fitted with hydraulic brakes and the control panel is shown in Fig. 7 on page 12.

2.8 Miscellaneous Controls – The necessary switches are provided to control the driving compartment heating and lighting, the frontal lighting, to dim the instrument lighting and the line indicator and train supply indicator lights. These are shown on Fig 6 page 11 together with the normal air and brake system gauges. An AWS reset button is provided, together with valves to control the warning horns and the windscreen washers and wipers.

2.9 Instrument and Indicators

2.9.1 Line Indicator 'L' – illuminated when the pantograph is in contact with a live overhead line and the main circuit breaker is 'set'.

INSTRUMENT LAYOUT
CLASS 86 LOCOMOTIVES

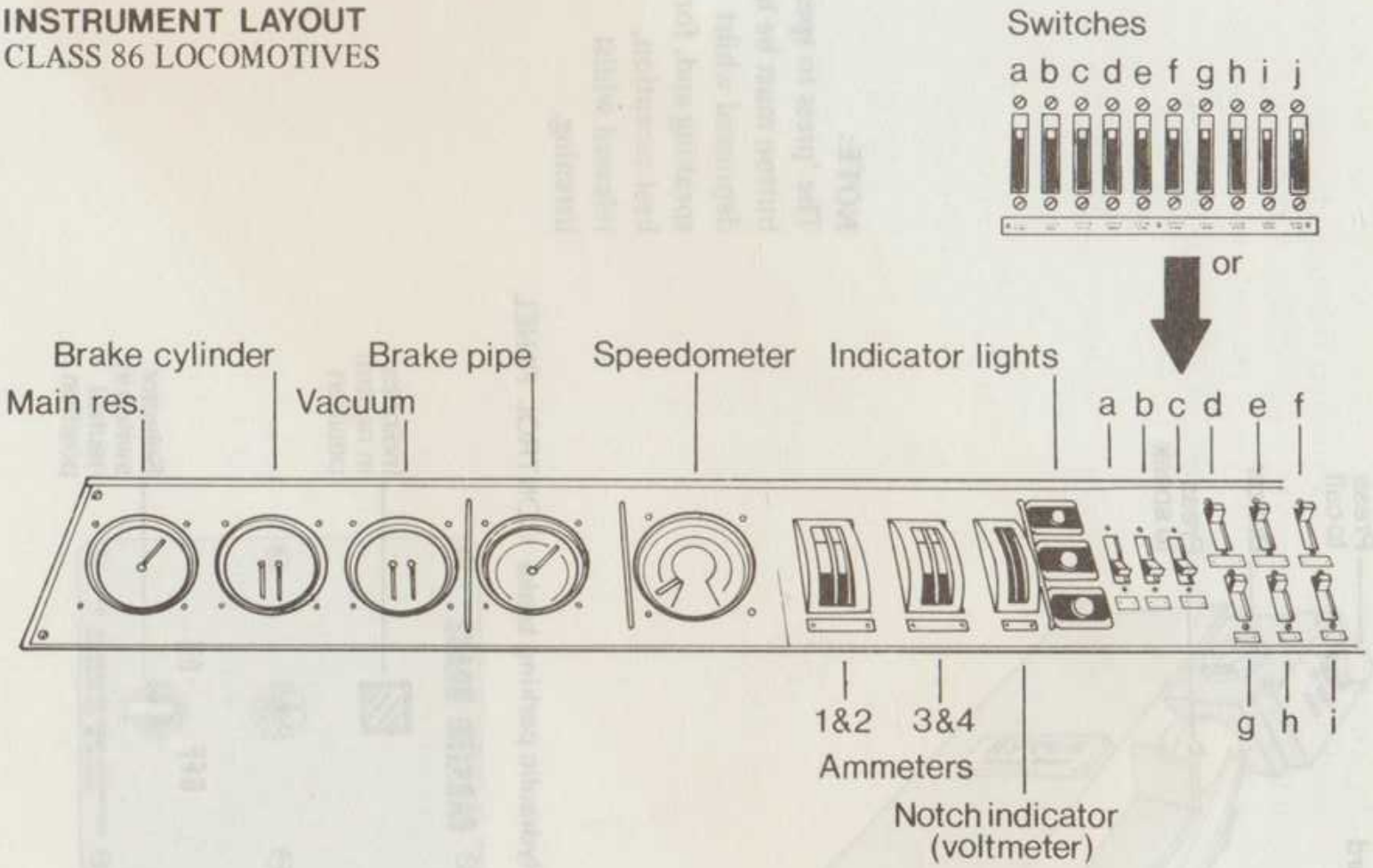
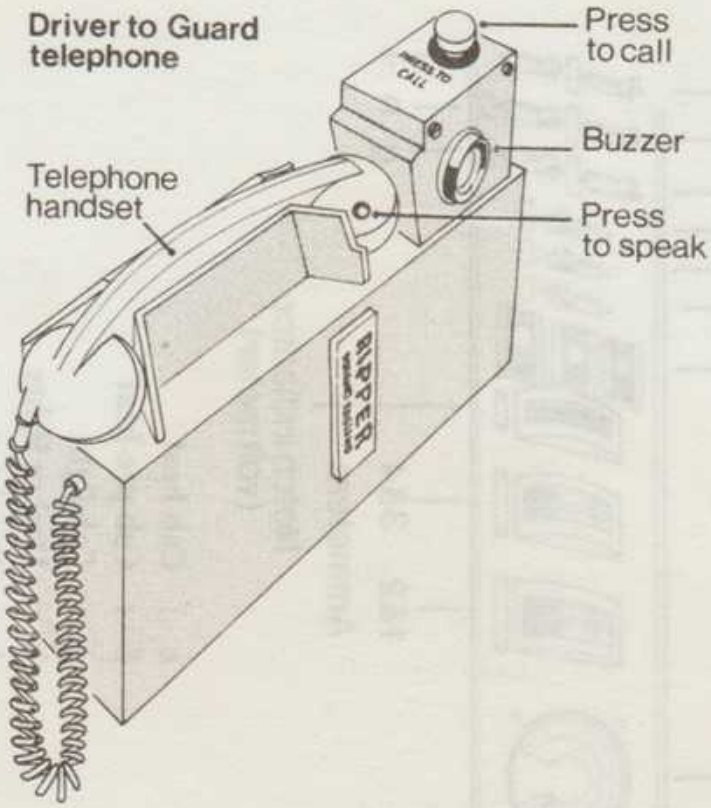


Fig. 6 Instrument Layout

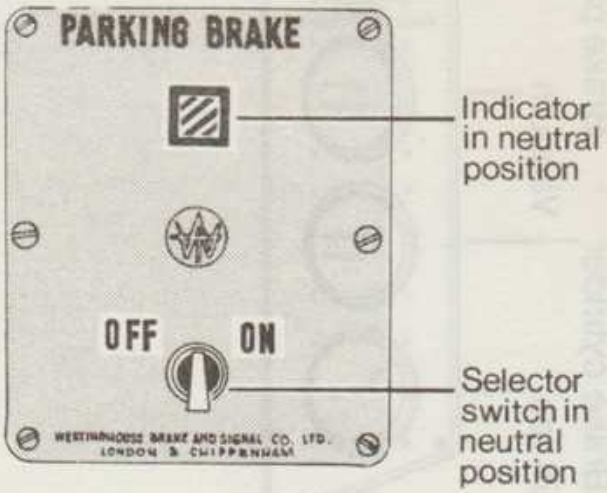
a : Instrument lights
b : Tail lights
c : Indicator lights
d : Foot warmer
e : Cab heat
f : Cab pre-heat
g : Cab light
h : Marker lights
i : Demister

Fig. 7 Class 87 locomotives



NOTE:
The 'press to speak' button must be held depressed whilst speaking and, for the best reception, released whilst listening.

Hydraulic parking brake CONTROL PANEL



2.9.2 Notch Indicator – this is calibrated as a percentage of the tap-changer notch position e.g. 100% corresponds to notch 38. On Classes 81, 86/1 and 85 graduations beyond 100% indicate traction motor weak field notches. Locomotives equipped for multiple working are provided with a second notch indicator to enable the Driver to observe the response of the second locomotive.

2.9.3 Ammeters – there are two dual indicating instruments to register the current in No. 1 and No. 2 traction motors and No. 3 and No. 4 respectively. Each has three sectors:-

RED – Overload
YELLOW – Short term motor rating
GREEN – Continuous motor rating

When accelerating rapidly from rest the current taken by the traction motors will necessarily be high and notches may continue to be taken whilst the needles remain in the YELLOW sector. The needles may momentarily 'peak' into the RED and then fall back into the YELLOW, however should the needles remain in the RED sector then the power controller MUST be notched down until the needles return to the YELLOW sector. Once speed has been built up the needles will normally fall to, and remain in, the GREEN sector.

The four needles should rise and fall simultaneously since all four traction motor currents are normally equal at any given instant. Should any pair of wheels slip then the current of the associated traction motor, rotating at the relatively higher speed, will fall and the ammeter needle of that motor will fall 'out of step' with the other needles thus giving a wheelslip indication.

The use of the anti-slip brake, and the automatic wheel slip control, is described in Section 6.

2.9.4 Fault Indicator Light – Normally DIM and becomes BRIGHT under certain fault conditions (with or without loss of traction power) to alert the Driver.

2.9.5 Train Supply Indicator Light – Normally ILLUMINATED when a train supply has been established and is EXTINGUISHED to alert the Driver.

2.9.6 Speedometer – The maximum speed of the locomotive MUST NOT be exceeded under power or coasting. The speed is measured by an alternator mounted on one axle end (other than Class 87) or by electronic means on Class 87.

3. EQUIPMENT WITHIN THE LOCOMOTIVE

3.1 Power Circuit Equipment – General Principles (see Fig 8 page 16)

When the main circuit breaker (4) is closed and the pantograph (3) is in contact with a live overhead line (2) carrying alternating current (a.c.) from the feeder station (1), the main transformer (5) is energised. The output of the transformer (A) is then 'tapped' at a number of points to provide the variable output, which is then rectified (B) to direct current (d.c.) and fed (C) to the traction motors (D).

The return current from the main transformer (5) then passes to earth brushes in contact with the axles (6) and thence via the wheels and running rails to the return conductor (7) back to the feeder station (1).

3.1.1 Main Circuit Breaker (ABB/VCB)

This is provided to isolate the locomotive equipment from the pantograph and since both the Air Blast Circuit Breaker (ABB) and Vacuum Circuit Breaker (VCB) are air-operated a ABB/VCB governor ensures that a pressure of at least 75 psi is available before the circuit breaker is closed. Should the pressure then drop to 59 psi then the circuit breaker will be opened.

3.1.2 Auxiliary Compressor

Are these pressures correct?

A small auxiliary compressor, powered from the battery, provides the initial pressure to raise the pantograph and to close the ABB/VCB. The auxiliary compressor governor stops the compressor when the pressure reaches 70 psi.

3.1.3 Pantograph

There are a number of different designs but the principle of operation remains the same, in that the pantograph frame is normally held down in a 'collapsed' condition by spring pressure. To raise the pantograph to enable the head to contact the

overhead line air pressure is applied to overcome the spring pressure.

NOTE: The operation of the main circuit breaker, auxiliary compressor and pantograph is described in detail in the companion publication BR. 33056/103.

3.2 Main Transformer

The current at 25kV (25,000 volts) collected by the pantograph flows through the primary winding of the main transformer and returns to the lineside feeder station.

This current induces a current to flow in the secondary winding which has a reduced number of 'turns' so that the output voltage is less than that of the primary winding i.e. it is a 'step down' transformer.

On Class 81 and 85 locomotives the secondary windings (low voltage) are 'tapped' at a number of points to obtain a range of 38 output voltages up to 1000v for train speed control.

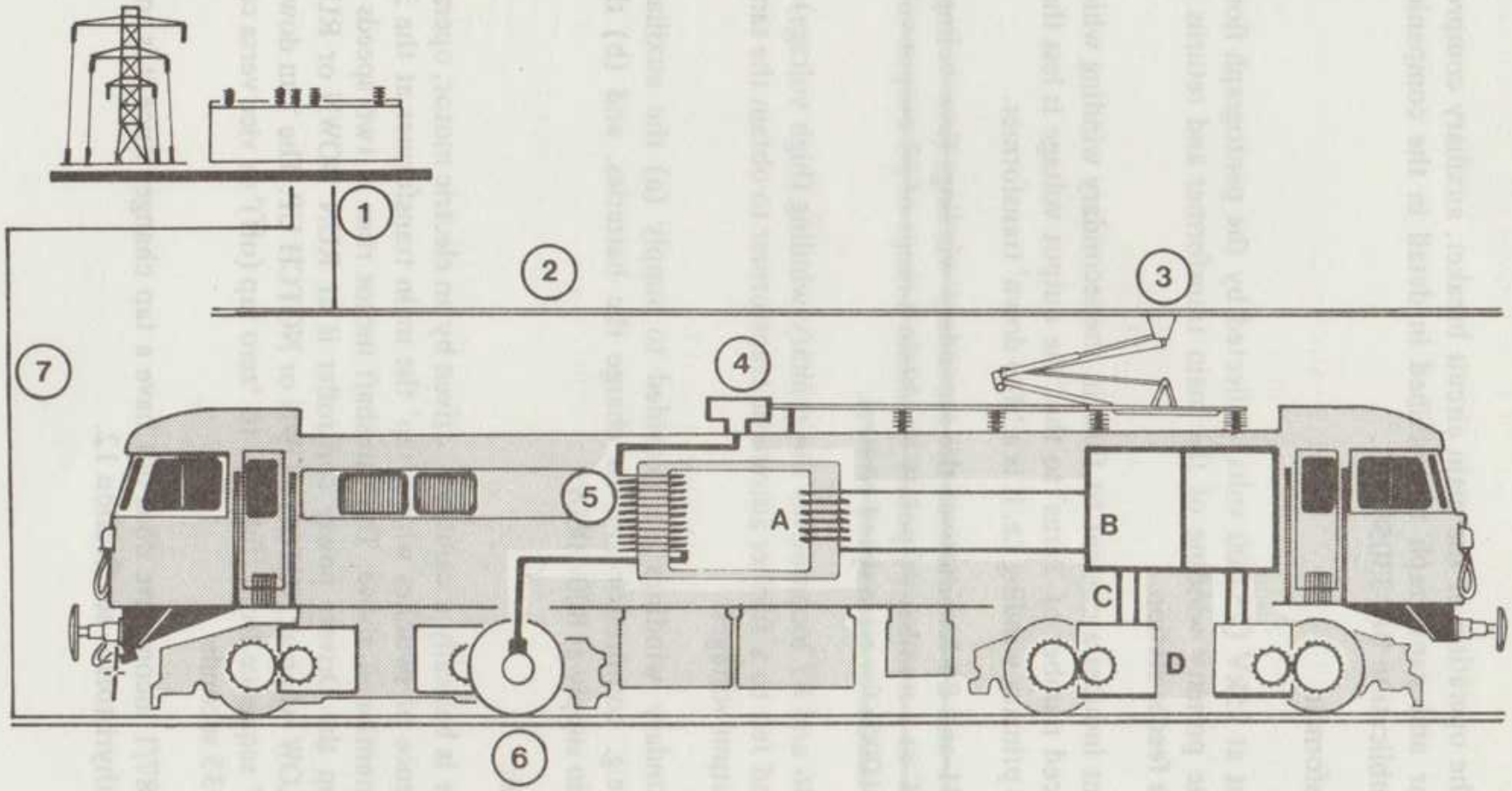
On Class 86 and 87 locomotives the primary winding (high voltage) is 'tapped' and fed to a further automatic transformer to obtain the same range of output voltages.

Other secondary windings are provided to supply (a) the auxiliary machines e.g. compressor and to charge the batteries, and (b) the electric train supply at 800-1000v.

3.3 Tap Changer

This device is basically a camshaft, driven by an electric motor, operating a sequence of switches which 'tap' the main transformer at the 38 positions mentioned above. The camshaft motor runs at two speeds – FAST when the Drivers power controller is at RUN DOWN or RUN UP and SLOW when at NOTCH DOWN or NOTCH UP. The 'run down' or 'run up' sequence from 'full tap' to 'zero tap (off)' or vice versa can take up to 35 seconds.

The Class 87/1 locomotive does not have a tap changer since it is controlled by thyristors – see Section 12.



1. Feeder station
2. Overhead line
3. Pantograph
4. Main circuit breaker
5. Main transformer (input)
6. Earth brush on axle
7. Return conductor – running rail to feeder station

A. Main transformer – (output)
B. Rectifier
C. Connection to traction motor
D. Traction motor

Fig. 8 Power Circuit Equipment – General Principles

3.4 Rectifiers

These convert the a.c. voltage derived from the main transformer into d.c. voltage for the traction motors. They consist of a number of diodes connected in a series/parallel formation and mounted on trays, cooled by air blown over them by a fan.

On Class 86 and 87 locomotives this air stream also cools the smoothing chokes (see below) and traction motors.

3.5 Smoothing Chokes

These are necessary to smooth out the output from the rectifiers to make it completely suitable for the d.c. traction motors.

3.6 Traction Motors and Associated Equipment

The four motors are connected in a series/parallel formation which enables the current to be balanced between each pair and for them to be isolated either in pairs or singly.

On Classes 81, 85, 86/1 and 87 weak fielding (field diversion) is provided to give an increased tractive effort at higher speeds. Classes 86/0, 86/2, 86/3 and 86/4 have traction motors specially designed to meet the required performance without the need for weak fielding.

All locomotives except Class 81 have traction motor contactors which are normally closed when the power controller is away from the OFF position but which are automatically opened under certain fault conditions to immediately isolate the motors electrically. Class 81 locomotives have a mid-position on the reverser switch (see below) which performs the same function.

The reverser switch is electro-pneumatically operated with, except on Class 81, just two positions 'forward' and 'reverse' selected by the master switch on the driving desk.

3.7 Auxiliaries

The electricity supply for the various auxiliary machines, such as the motors which drive the various cooling fans, or the auxiliary services is taken either from the secondary winding of the main transformer or by a 'tapping' from the primary winding. In the latter case an auxiliary transformer is required to produce the necessary output of 140/135 volts a.c. which may then need to be rectified for d.c. machines.

3.7.1 Class 81 & 85 locomotives

A. Induction motors (a.c.) at 140 volts (nominal) drive:-

Transformer Oil Pump (1)	Circulates oil through transformer tank and radiators to cool the main transformer.
Transformer Fans (2)	Draws air in through bodyside louvres to force-cool transformer oil radiators.
Rectifier Fans (2)	Draws air from bodyside louvres to cool the rectifiers by passing air through their cabinets.
Traction Motor Blowers (2)	Each draws air from bodyside louvres and blows it through ducting and flexible bellows to the traction motors of one bogie. They run only when the master switch is at FOR or REV.

B. D.C. motors fed direct from the battery supply (110v) drive:-

Auxiliary Compressor (1)	Provides initial pressure to raise pantograph and close main circuit breaker.
Exhauster No. 2	Runs continuously whilst locomotive is in service.
Camshaft Motor (1)	Drives the tapchanger.

C. D.C. motors fed from the auxiliary transformer via a rectifier at 120 volts (nominal) drive:

Main Compressor (1)	Supplies the main reservoir system once the pantograph is raised.
Exhauster No. 1	Runs only while the overhead line supply is available.

D. Other auxiliary services supplied from auxiliary transformer at a nominal 140 volts:

Battery Charger	Maintains battery in a charged state and supplies the battery load when the overhead line supply is available.

E. Locomotive lighting is from the battery supply at 110 volts d.c.

F. Class 85 locomotives only:

To drive the fan which cools the braking resistors during rheostatic braking (see Clause 3.8), a d.c. motor is connected in parallel with the braking resistor and the traction motor armature.

3.7.2 Class 86 & 87 locomotives

A. Induction motors (a.c.) fed from the auxiliary transformer at 135 volts (nominal) drive:

Transformer Oil Pump (1)	Circulates oil through transformer tank and radiators to cool the main transformer.
Traction Motor/ Smoothing Choke/ Rectifier Blower (4) (group blowers)	Each draws air from bodyside louvres to force-ventilate a traction motor, a smoothing choke and the rectifiers in each of the four power groups.

This 135v supply also provides the driving compartment heating/ventilation, cooker/boiling ring etc.

B. D.C. motors fed from two sources (see below) drive:

Transformer/ Rheostatic Brake Fans (2)	Draws air from bodyside louvres to (a) force-ventilate the transformer radiators. (b) blow air across the resistor banks during rheostatic braking.

The source for (a) is the auxiliary rectifier at 120v, whilst (b) applies during rheostatic braking and is a 'tapping' at 470v (maximum) from the traction motor armature circuit.

C. D.C. motors fed direct from the battery supply (110v) drive:

Auxiliary Compressor (1)	Provides initial pressure to raise pantograph and close main circuit breaker.
Exhauster No. 1 (Class 86)	Enables this exhauster to run continuously even when the overhead line supply and hence the auxiliary rectifier supply is not available.
Camshaft Motor (1)	Drives the tapchanger.

D. D.C. motors fed from the auxiliary rectifier at 120 volts (nominal) drive:

Main Compressor (1)	Supplies the main reservoir system once the pantograph is raised.
Exhauster No. 2 (Class 86)	Runs only while the overhead line supply is available.

NOTE: Exhauster No. 1 also runs from the auxiliary rectifier when the overhead line supply is available.

Hydraulic Parking Pump Motor (where fitted).	Pressurises the oil to operate the hydraulic parking brake.

E. The battery charger, which maintains the battery in a charged state and supplies the battery load when the overhead line supply is available, is supplied from the auxiliary winding on the main transformer at a nominal 270 volts.

F. Locomotive lighting, other than the headlight, is taken from the battery at 110 volts d.c.

G. The headlights are supplied from the main transformer auxiliary winding via a step-down transformer at 12 volts (nominal).

3.8 Rheostatic Brake Equipment

On Class 85, 86 and 87 locomotives the four traction motors may be reconnected electrically to serve as generators driven by the road wheels. With their armatures rotating and the traction motor fields energised (known as excitation) a voltage is generated and this is fed to braking resistors. This places a load on the armature which produces a braking effect on the locomotive and by using the tapchanger to automatically vary the strength of field excitation the braking effect be varied. Thus the rheostatic brake of the locomotive is matched to the normal indirect (or proportional) air brake application demanded by the position of the drivers brake valve and in fact should a failure of the rheostatic brake equipment occur even whilst the Driver is braking the normal indirect air brake application will be automatically established.

There is a reduced rate of brake block wear on the locomotive and therefore a saving in that the kinetic energy of the train is converted to electrical energy for braking which is dissipated as heat through the braking resistor – hence the need to cool them.

3.8.1 Rheostatic braking is initiated by electrical contacts within the Drivers brake valve, which close when it is moved from the RUNNING position to FIRST APPLICATION. The first movement of the brake valve must be direct to FIRST APPLICATION and under no circumstances must the brake valve be positioned anywhere between that position and RUNNING.

3.8.2 The contacts within the brake valve operate a Power/Brake changeover switch which, once the tapchanger has run back to the "off" position, will alter the traction motor circuits to enable them to act as generators.

3.8.3 The normal indirect air brake application is initiated on the locomotive, indicated by a rise of the bogie 1/bogie 2 brake cylinder gauge needles.

3.8.4 The air pressure passing to the relay valves in the brake system is 'tapped' to provide a 'signal' to the rheostatic brake actuator which adjusts the tapchanger position to provide a matching rheostatic braking effort.

3.8.5 Once the required rheostatic braking effort has been established the indirect locomotive air brake application is released, other than for approximately 5 p.s.i. which is retained to maintain the brake rigging taut in readiness for a renewed application should the need arise.

3.8.6 As train speed falls the rheostatic brake naturally has less effect i.e. the traction motors are generating less, and at only a few m.p.h. there is an automatic reversion to the indirect brake, indicated of course by the rise of the bogie 1/bogie 2 brake cylinder gauge needles.

3.8.7 If the brake valve is returned to the RUNNING position whilst rheostatic braking is taking place e.g. if it has just been necessary to reduce speed to 60 m.p.h. for a speed restriction, then the actuator will run the tapchanger to 'Off' at a controlled rate, whilst the Power/Brake switch changes the electrical connections in the traction motor circuits to enable them to act as motors again.

3.8.8. Under no circumstances must a higher locomotive brake cylinder pressure be superimposed on a rheostatic brake application e.g. by application of the direct (straight) air brake of the locomotive.

3.9 Automatic Protection Equipment

Wherever electrical equipment is used, a protection system must be employed to ensure that under abnormal conditions which might cause damage to the equipment or endanger personnel, the equipment may be isolated – in some cases automatically – from the electrical supply. Such equipment is designed to work correctly in definite temperature conditions, if these are too low or they rise beyond a certain figure, then its electrical and mechanical properties may be severely impaired. Increases in temperature may be caused by earth faults, short circuits failure of cooling systems or continual overloading of the electrical equipment and the various safety devices either cut off power immediately to safeguard it, or alert the Driver by means of warning lights.

3.9.1 Transformer

A. Primary Overload Relay

This measures the current flowing from the pantograph to the main transformer primary winding and if this exceeds a predetermined figure the relay will operate to open the main circuit breaker.

B. Buchholz Relay

Should the oil which is pumped through the transformer begin to decompose then gas will be produced and this will be detected by the alarm contacts of the relay – First Stage. An initial warning of the build up of gas is then given by the brightening of the general fault indication light on the driving desk and the appropriate indication on the Fault Indication Panel (F.I.P.).

If the condition becomes more serious then pressure built up in the oil by local overheating will close trip contacts within the relay to open the main circuit breaker – Second Stage. These trip contacts can only be reset by maintenance staff.

C. Oil Thermostats

These are temperature sensitive switches which operate when the transformer oil temperature rises beyond preset values.

On Class 81 and 85 locomotives a two-stage detection system is provided:

First Stage — At 85 degrees C the cooling fans and pumps will run continuously, even with the master switch at OFF. The general fault indication light on the driving desk brightens to alert the Driver.

Second Stage — At 95 degrees C traction power is lost but, since the cooling fans and pumps still run continuously as above, the equipment should cool quite quickly and in certain circumstances it will be possible to regain traction power and so avoid the need to request assistance.

On Class 86 and 87 locomotives the first indication of high transformer oil temperature will be loss of traction power and the tapchanger will run back to, and remain at, 'Off'. It will not be possible to regain traction power or 'notch up' until the temperature has reduced to its normal working level.

D. Oil Flow Switch

No tranformer alarm light!

These are fitted to Class 86 and 87 locomotives and operate should the oil circulation through the transformer cease then the tapchanger will run back to 'Off', with loss of traction power, and further 'notching up' will not be possible until oil circulation is restored.

E. Secondary Overload Relays

These are located in the circuits from the secondary windings of the main transformer and if the current becomes excessive in any one secondary circuit the relay will trip to open the main circuit breaker. Additionally on Class 86 and 87 locomotives the traction motor contactors will open to additionally protect the motors.

F. Rectifier Surge Suppression

This device protects the rectifiers against high voltage surges which could permanently damage them and, on Classes 81 and 85, is in the form of a fuse. Traction power will not be lost but the desk general fault indicator light will brighten together

with the appropriate indication on the F.I.P. Arrangements should be made to take the locomotive out of service at the next convenient point.

Protection is provided on Class 86 and 87 locomotives but no indication is given to the Driver therefore no action is required on his part.

3.9.2 Traction Circuits (d.c.)

A. Traction Motor Overload Relays

These operate should the current to any one motor exceed the permitted maximum and have the following effects:-

Class 86 and 87 – traction power will be lost ONLY on the affected motor circuits therefore some power will still be available. Furthermore, it will not be possible to 'notch up' further until the overload relay has been reset (by depressing the pan up/reset button) or the affected circuit has been isolated.

Indication is given by the brightening of the desk general fault indicator light and the ammeter for the motor(s) concerned registering zero.

Class 81 and 85 – there will be complete loss of traction power and power cannot be regained until the relay has been reset or the affected circuit has been isolated.

C. Earth Fault Relay

This relay will operate to open the main circuit breaker and bring about loss of traction power if any of the traction motor circuitry becomes earthed e.g. a breakdown of insulation.

It may be reset by depressing the pan up/reset button but if the main circuit breaker opens again when traction power is re-applied then it may be possible to isolate the affected circuit by isolating the traction motors in turn.

D. Rheostatic Brake (Brake Excitation) Overload

This protects the traction motor armatures from excessive current flow when the motors on Class 85, 86 and 87 are connected for rheostatic braking. Should the device trip then the

normal indirect locomotive brake cylinder pressure is automatically applied to ensure that the braking effort is maintained despite the loss of the rheostatic brake. The relay is automatically reset when the tapchanger has run back to the 'Off' position and, unless the fault persists, the rheostatic brake will again be available next time the brake valve is moved to an application position. The rheostatic brake may be isolated if necessary by the switch provided.

3.9.3 Auxiliary Machines

A. Transformer/Rectifier Fan Motors

Proving relays detect loss of current to the motors driving the transformer, choke and restifier fans and operate to brighten the desk general fault indicator light and the appropriate light on the F.I.P.

Additionally on Class 86 and 87 locomotives a further proving relay will detect any excessive voltage to the motors and run down the tapchanger to the 'Off' position, bringing about loss of traction power.

B. Traction Motor/Rectifier Blower Motors

Similar proving relays, giving the same indications as described in A. above, are provided.

Additionally on Class 86 and 87 locomotives if current to a traction motor blower is lost e.g. a MCB has tripped, then the corresponding traction motor is automatically isolated. Traction power will still be available from the remaining motors but full power will not be obtainable unless the current can be restored e.g. the MCB can be reset.

~~C. Rectifier Fan Circuit Relays~~

~~Applicable to Class 81 and 85 only – these are further proving relays giving similar indications to A. above and bringing about, additionally, loss of traction power.~~

D. Auxiliary Circuits

These are protected either by fuses or M.C.B's.

E. Control Circuits

These are protected by battery fuses (Class 81 and 85) or by battery M.C.B's (Class 86 and 87). In addition there are two battery isolating switches, the one for normal use being within the locomotive whilst an external Emergency Battery Isolating Switch (E.B.I.S.) is provided at solebar level. Operation of the EBIS will open the main circuit breaker.

4. TO MOVE A LOCOMOTIVE IN DEPOTS, YARDS, ETC BEFORE ENTERING TRAFFIC.

4.1 The locomotive must either have been prepared in accordance with the instructions in BR. 33056/101, or taken over in a fully prepared condition.

4.2 If the movement does not immediately follow preparation then check that:-

4.2.1 The automatic air brake applies fully when the brake valve is moved to the EMERGENCY position.

4.2.2 The direct air brake fully applies when the brake valve is moved to the full ON position.

4.2.3 The brake cylinder pressure rises to its maximum on both bogies on each of the above applications.

4.2.4 The repair book contains no serious defects that have not been signed off.

4.2.5 No depot pipes and cables are connected, nor lying across rails, that no NOT TO BE MOVED targets or red flags are attached and that NO STAFF are working on, adjacent to, or underneath the locomotive.

4.2.6 All scotches have been removed.

4.2.7 The marker lights and tail lights are illuminated for the direction of travel required.

NOTE: The headlight (where fitted) should be switched ON when the locomotive is in traffic.

4.2.8 The brake selector switch is at AIR PASSENGER or VACUUM PASSENGER (Class 81, 85 and 86), or PASSENGER (Class 87).

4.3 Make a holding application of the direct air brake and release the parking brake.

4.4 Ensure that no other traction units, vehicles or equipment are foul.

4.5 When ready to move, depress the DSD pedal, move the master switch to FORWARD or REVERSE as required and slowly release the direct air brake as the power controller is moved 'to and fro' between HOLD and NOTCH UP and movement commences.

NOTE: POWER MUST NOT BE APPLIED IF THE LOCOMOTIVE IS MOVING IN THE DIRECTION OPPOSITE TO THAT IN WHICH THE MASTER SWITCH IS POSITIONED.

5. ATTACHING TO A TRAIN

NOTE: THIS OPERATION MUST BE PERFORMED FROM THE DRIVING COMPARTMENT NEAREST TO THE TRAIN

5.1 Approach the train and stop when the gap between the buffers is 6 feet.

5.2 On receiving a hand signal from the person who is to couple up, apply minimum power and make gentle contact with the train.

5.3 Use additional power to compress the buffers and then apply the direct air brake. Immediately the air brake application is established move the power controller of OFF.

5.4 When the person who has coupled up is clear release the direct air brake application.

5.5 Change ends in accordance with the instructions in BR. 33056/101 but in addition:-

5.5.1 Check the position of the brake selector switch as necessary to suit the type of train to be worked.

5.5.2 Check that the coupling operation has been performed correctly.

6. TO MOVE A LOCOMOTIVE WITH A TRAIN ATTACHED INTO SERVICE

6.1 Move the master switch to FORWARD whilst keeping the DSD pedal depressed and switch the headlight ON.

6.2 Once the signal to start has been received move the straight air brake to OFF or the automatic air brake to RUNNING i.e. whichever brake has been used to hold the train whilst stationary.

6.3 Move the power controller 'to and from' between HOLD and NOTCH UP as the brakes are released until the current value for the desired tractive effort is reached, so that movement commences as the brakes are fully released.

6.4 If the train is standing on a rising gradient, or the locomotive has moved in the opposite direction to that set by the master switch, then the procedure outlined in 6.3 must be repeated until the right combination of traction current and graduated release of the direct air brake is found by experience. Drivers must take into account the gradient, load of the train, rail conditions etc.

6.5 IF, AT ANY TIME WHEN POWER IS APPLIED, THE WEIGHT OF THE TRAIN BRINGS THE MOVEMENT TO A STAND OR THE TRAIN MOVES BACK IN THE OPPOSITE DIRECTION TO THAT INTENDED, THEN THE POWER CONTROLLER MUST IMMEDIATELY BE CLOSED AND A SIMULTANEOUS FULL APPLICATION OF THE AUTOMATIC AIR BRAKE MUST BE MADE.

If the load of the train is in accordance with that specified then the train should be checked for dragging brakes etc. before any repeated attempts to start the train are made.

6.6 When rail conditions are poor the anti-slip brake should be used in anticipation, and the button on the driving desk should be kept depressed during initial acceleration. This feature supplies approximately 15 psi to the locomotive brake cylinders – sufficient to 'rub' the blocks on the wheel and so 'hold back' a slipping axle.

6.7 If wheelslip takes place this will be indicated by the motor ammeter needles becoming 'out of step' as the motor associated with the wheels that are slipping will be taking less current than those which are still providing the tractive effort.

Other than on Class 86 and 87 locomotives, power must be reduced by 'notching down' as the anti-slip brake is applied to arrest the slipping wheels. Under extreme conditions it may be necessary to allow some controlled wheelslip (to avoid stopping on a gradient etc.), but the wheelslip MUST NOT be allowed to become excessive or damage to the wheels, rails and possibly the traction motors will result. The anti-slip brake must be kept applied under these conditions and tractive effort kept as constant as possible by steady notching.

6.8 Class 86 and 87 locomotives are fitted with equipment for the detection and automatic correction of wheelslip. By measuring the current taken by a pair of traction motors the anti-slip brake is automatically applied and the tapchanger is automatically 'run down' (irrespective of the position of the power controller) whenever the current differs by 200 amps. Once motor currents are again equal the anti-slip brake application is automatically released and control of the tapchanger is returned to the power controller, allowing the Driver to 'notch up' gradually.

Provision is still made for manual operation of the anti-slip brake by means of a push button on the driving desk and use of this 'overrides' the automatic 'run down' of the tapchanger, thus enabling the Driver to allow some controlled wheelspin as described in 6.7 above BUT ONLY AT LOWER SPEEDS.

The anti-slip button MUST NOT be used at any speed above 60 m.p.h. because it alone will not always be effective in arresting wheelslip at high speeds, and to 'override' the automatic 'run down' feature could allow the speed of the traction motor driving the slipping wheels to rise to a figure where serious damage is caused e.g. bursting of the armature

High speed wheelslip and automatic correction may go unnoticed therefore when running at high speed when rail conditions are poor the Driver should occasionally check that the desired tapchanger position is still being held. It may be that it has 'run down' several notches automatically and therefore needs 'notching up' again.

6.9 To accelerate at the maximum rate the ammeter needles should not normally be higher than the division between the yellow and red sectors of the meters, and the current should be allowed to fall (as speed increases) by approximately 200 amps before the next 'notch up' is taken.

NOTE: If the ammeter needles enter the red sector, a further notch should not be taken until the needles fall to approximately 200 amps below the yellow/red division. If the needles do tend to remain in the red sector for more than a few seconds then the Driver must 'notch down' until the yellow/red division is reached.

To maintain a high average accelerating current it will be noted that the rate of which notches can be taken increases as the speed rises, therefore if the current falls off quicker than individual notches can be taken then the 'run up' position on the power controller should be used.

Notching should be discontinued before the desired speed is reached, especially if the accelerating current is high. If speed tends to rise above that required then notches should be reduced by either 'notching down' or 'running down'.

If maximum speed is required it is usual to take all available notches including the weak field notches on locomotives so equipped, unless hauling a light load or the gradient is falling. The notch indicator will show the approximate number of notches taken and when the needle is steady at the top of the scale, indicating that weak field has been taken, the Driver should go through the motions of taking one further notch to ensure that the second stage of weak field (on locomotives so equipped) has been brought in and full power is being developed.

When all available notches have been taken or when the desired speed is attained, the power controller should be moved to the HOLD position. Care must be taken to ensure that the maximum speed of the locomotive is not exceeded and that line limits are observed.

If the desired speed can be maintained with reduced current to the traction motors, or conditions permit a gradual drop in speed, the tapchanger should be run down by use of the 'notch down' or 'run down' position of the power controller prior to actually moving it to OFF. This avoids the jolt or 'snatch' that would otherwise be experienced when the tractive effort exerted by the locomotive is suddenly cut off. It is quite in order to shut off power at any tapchanger position, but the lower the current being taken by the motors at that instant, the less noticeable the snatch will be.

NOTE: Once the power controller has been placed in the OFF position it is not possible to reapply power until the tapchanger has returned to its 'minimum volts' position – from 'full tap' (100%) this can take as long as 35 seconds.

IMPORTANT: Under no circumstances must the master switch be moved to the OFF position, nor must the opposite direction be selected, whilst the locomotive is moving and on coming to a stand it is desirable to wait a few seconds before so doing.

7. BRAKING OF A TRAIN IN SERVICE

7.1 In general braking should be in accordance with Instructions contained in BR. 33056/3.

8. TO REVERSE THE LOCOMOTIVE

8.1 Return the power controller to OFF.

8.2 Apply the brakes to hold the locomotive stationary.

DO NOT ATTEMPT TO REVERSE WHEN THE LOCOMOTIVE IS MOVING.

8.3 Move the master switch to the opposite direction of travel.

8.4 Release the brakes and open the power controller as required.

9. LEAVING A LOCOMOTIVE ON A RUNNING LINE

9/10/96

~~9.1 It it is necessary to carry out Rules or other duties which are away from the immediate vicinity of the train then:-~~

~~9.1.1 Move the automatic air brake valve to EMERGENCY.~~

~~9.1.2 Move the master switch to OFF, remove and retain the master key.~~

~~9.1.3 Apply the parking brake.~~

~~IMPORTANT: If Mark 3 coaches are being hauled and the brakes are applied in the train, the automatic air brake valve must be moved to FULL SERVICE and not EMERGENCY. This will retain sufficient air pres-~~

~~sure in the brake pipe to enable the audible indicators to be heard if a passenger communication valve has been operated.~~

10. DETACHING THE LOCOMOTIVE FROM THE TRAIN

10.1 Move the automatic air brake to EMERGENCY and ensure that the Electric Train Supply (E.T.S.) is switched OFF.

10.2 Indicate to the person that is to uncouple that the brake pipe hoses and ETS jumper cables (where applicable) may be uncoupled.

10.3 When that person indicates that the brake pipe hoses have been uncoupled and the locomotive air brake pipe cock has been closed, or the vacuum hose pipe has been placed on the locomotives dummy coupling, and that he is ready for the buffers to be compressed then move the automatic air brake valve to RUNNING.

10.4 When the locomotive brakes have released move the master switch to the direction required to 'ease up' and apply sufficient power to compress the buffers. Apply the direct air brake and IMMEDIATELY move the power controller to OFF.

10.5 When the person has completed the uncoupling operation, and has given a hand signal to 'draw away', move the master switch to the required direction, release the direct air brake and move the locomotive away as required.

NOTE: If the train is not fitted with continuous brakes then the person who is to uncouple will apply sufficient handbrakes to hold the train whilst buffers are compressed.

11. AUTOMATIC POWER CONTROL & DRIVING TECHNIQUE THROUGH NEUTRAL SECTIONS.

11.1 Automatic Power Control (A.P.C.) Equipment

To avoid severe arcing at the pantograph when passing through a neutral section, electrical power equipment on the locomotive must be 'shut off' before the pantograph passes from the 'live' contact wire to the 'dead' section and this is done automatically.

An APC receiver on the locomotive passes over track inductors strategically placed to open ('trip') and close ('set') the main circuit breaker before and after, respectively, the neutral section.

The locomotive main circuit breaker is opened by a track inductor (magnet) positioned approximately 100 feet in advance of the neutral section being approached. A second track inductor positioned 40 feet beyond the neutral section will re-set the main circuit breaker when the pantograph runs onto the next section of live contact wire.

The track inductors are mounted in pairs outside the running rails on the sleeper ends, whilst the APC receiver on the locomotive is fitted to the inner end of No. 1 bogie, and will pass directly over one or other of the pair of track inductors.

11.2 Neutral Sections

The overall length of the 'dead' section is only 15 feet and under no circumstances can these sections be energised, therefore the utmost care must be exercised to ensure that neutral sections are approached with sufficient speed for the locomotive to coast through.

Drivers must familiarise themselves with the geographical position of all neutral sections, identification being assisted by the track inductors positioned on the sleeper ends.

11.3 Automatic Power Control (APC) Sequence

When passing through a neutral section the Driver will be aware of the following sequence occurring:-

11.3.1 As the locomotive passes over the first track inductor the main circuit breaker opens and the line indicator light is extinguished. The tapchanger will run down to the minimum volts position (if not already there).

NOTE 1: It is desirable, though not essential with passenger or close-coupled fully braked freight trains, that the tractive effort exerted by the locomotive is low whilst passing over this first inductor. This will avoid a snatch between the locomotive and train as the main circuit breaker cuts off power. The power controller should be moved to the OFF position (if not already there) as the line indicator light is extinguished.

NOTE 2: Faults occasionally occur on the APC equipment resulting in the main circuit breaker NOT opening when running through a neutral section. Providing the power has been 'run off' prior to the neutral section no damage will normally occur, but it is helpful to maintenance staff if Drivers report mal-operation of the APC equipment. This will be revealed by the line indicator light remaining ILLUMINATED at a neutral section, at all but the lowest speeds, instead of being EXTINGUISHED for a second or two as it would normally.

11.3.2 As the locomotive passes over the second track inductor the locomotive main circuit breaker will reclose, provided the tapchanger has reached the minimum volts position, and the line indicator light will again become ILLUMINATED.

Power cannot be re-applied until the tapchanger has returned to the minimum volts position.

NOTE When re-applying power one or two individual notches should be taken and then the 'run up' should be used until the desired tractive effort is obtained. Where trains are not close-coupled, or not fully braked, care should be taken to extend the train before applying high tractive effort.

11.4 Neutral Sections – Driving Technique

It will be appreciated that technique to be adopted when traversing neutral sections has to be varied to suit particular circumstances. For instance if speed is low on approach, it is obviously desirable to maintain power 'on' for as long as possible so as to avoid coming to a stand in the 'dead' section.

If power will be required as soon as possible after leaving the section e.g. approaching a rising gradient, the tapchanger must be run down sufficiently early so as to allow time for it to reach minimum volts position by the time the locomotive passes over the second track inductor.

11.4.1 Passenger and Close-Coupled Freight Trains (Locomotive under power for as long as possible prior to the neutral section)

(a) Keep power controller at a suitable notch for the required acceleration.

(b) When the line indicator light is EXTINGUISHED move the power controller to the OFF position.

(c) When the line indicator light is again ILLUMINATED, and if acceleration is required, 'notch up' or 'run up' as conditions demand.

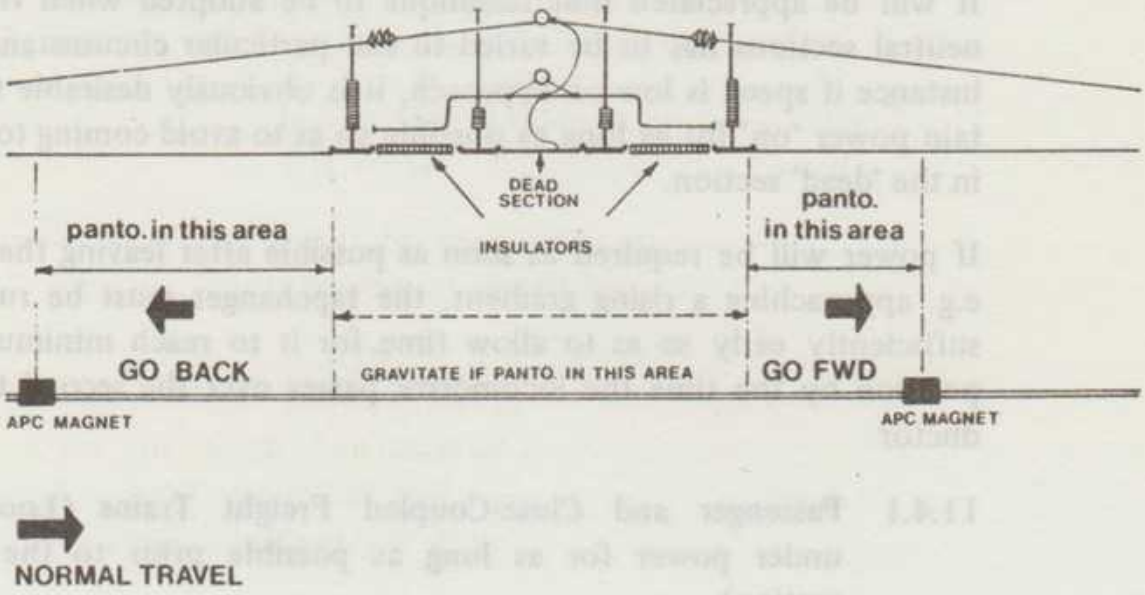
11.4.2 Freight Trains not close-coupled

(a) On approaching the neutral section power should be reduced by 'notching down' and finally moving the power controller to OFF in such a manner that power is kept 'on' as long as possible while at the same time avoiding sudden power reductions, which cause unwanted 'buffering-up' and 'snatching' of couplings.

11.4.3 Coasting through a Neutral Section

With any type of train it is in order to brake through a neutral section if circumstances demand, however use of the automatic air brake should be avoided whenever possible. Every effort should be made to approach them at a speed sufficient to enable the train to coast through and such that a brake application is not normally required.

11.5 Train at a stand between Neutral Section Track Inductors



If a locomotive should inadvertently come to a stand between the track inductors/magnets then the Driver must

(a) Move the power controller to the OFF position.
(b) Depress the pan up/reset button.
(c) Check the line indicator light.

If the line indicator light IS ILLUMINATED note the position of the pantograph in relation to the insulated 'dead' section of the overhead line and proceed as described in Item 11.5.1 or 11.5.2.

If the line indicator light IS NOT ILLUMINATED proceed as described in Item 11.5.3.

11.5.1 If the pantograph HAS passed over the 'dead' section and is between the insulator and the second track magnet then press the pan up/reset button and then:-

(a) Notch up to move the train slowly forward.

NOTE: Within at least 40 feet, as the APC receiver passes over the second track magnet, the main circuit breaker will open ('trip') and the line indicator light will be extinguished.

(b) When the line indicator light is EXTINGUISHED move the power controller to OFF.

(c) Depress the pan up/reset button. The line indicator light will ILLUMINATE and the train may proceed normally.

11.5.2 If the pantograph HAS NOT passed over the insulator and is between the first track magnet and the 'dead' section then:-

(a) Notify the Signalman of the precise circumstances and request permission to reverse the train approximately 300 feet.

NOTE: In some areas the Electrical Control Operator may be contracted, who must be asked to obtain permission (from the Signalman) to reverse the train.

(b) When permission has been received select reverse and 'notch up' to move the train slowly back.

NOTE: Within at least 100 feet, as the APC receiver passes over the track magnet, the main circuit breaker will open ('trip') and the line indicator light will be EXTINGUISHED.

(c) When the line indicator light is extinguished move the power controller to OFF.

(d) Depress the pan up/reset button. The line indicator light will ILLUMINATE and the train may continue to reverse until there is sufficient distance, between the first track magnet and the train, to enable sufficient speed to be built up to enable the train to pass through the neutral secton.

11.5.3 If the line indicator light IS NOT ILLUMINATED, because the pantograph is on an insulator or the earthed mid-position of the neutral section, then:-

(a) Depress the pantograph down button.

(b) Release the brakes and see if the gradient will enable the train to gravitate sufficiently for the pantograph to clear the 'dead' section.

NOTE: If on a rising gradient it will then be necessary to obtain permission to reverse the train further as described in Item 11.5.2.

(c) If the train will not gravitate sufficiently for the pantograph to clear the 'dead' section notify the Signalman/ Electrical Control Operator and request assistance.

NOTE: Secure the train as described in Section 9.

12. THYRISTOR CONTROLLED LOCOMOTIVE 87101

Whereas the conventional a.c. electric locomotive has a tapchanger to select the traction motor voltage according to the position of the Drivers power

Must be in direction to operate parking brake, buzzer then sounds when
p/brake on and in direction

controller, as described in Clause 3.3, this locomotive uses thyristors to control the voltage.

Thyristors are, in effect, solid state rapid action switches which have no moving parts and so require little maintenance.

The current in the overhead line is 50 cycle, single phase, alternating current i.e. the voltage (and current) 'cycles' from maximum to minimum and back fifty times each second. A thyristor is able to conduct electricity through all or part of the cycle, as required, and is so controlled that for small voltages it only conducts for a brief portion of each cycle whereas for maximum voltage it conducts over the whole cycle. The resulting 'pulses' of electricity are then rectified, as usual, to produce the direct current for the traction motors.

The thyristor control system can work in either of two methods, or 'modes' as they are called:-

Note, when → opening power controller from off

(i) Manual Mode – which gives a series of voltage steps like a tapchanger but more smoothly so as to reduce the chances of wheelslip.

(ii) Advance Mode – in which the controls can be set to give a constant current (tractive effort) up to a set maximum speed. This mode is not yet in general use except under trial conditions.

Notch is immediately put on

controller is now like a 90

This locomotive is equipped to work in multiple with other a.c. locomotives but the control system may ONLY be used in the MANUAL mode.

In Manual - when about to brake power can only be run down to first top, when brake valve moved, power brake switch knocks off top, to regain power, controller must be put to off.

87101 additional MCB.

Electronics if taps :-

With power on — loss of power, desk fault light up

" " off - FIP lights,

BCCB

TDCB

} no effect at all, what are they?

either one power pack isolating each causes complete loss of power!